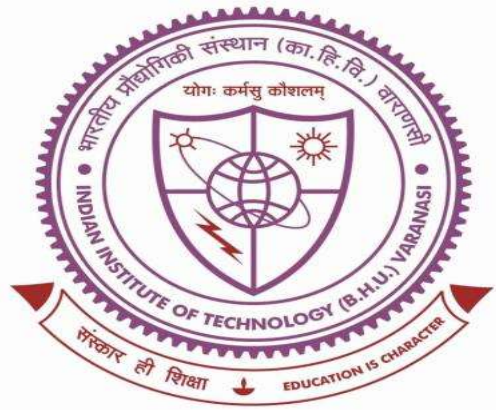
Biodegradation of Congo red dye in moving and packed bed bioreactors: Process optimization and kinetic modeling



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By

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Chapter 6

Summary of the thesis and future scope

6.1. Summary of the work

In the current work, various potential bacterial species were isolated from textile industry dye contaminated soil for the biodegradation of Congo red dye in moving and packed bed bioreactors. The various bacterial species were isolated from dye contaminated soil and used for Congo red dye biodegradation. Among them, two bacterial species KLM1 and KLM2 were found to be more effective for Congo red dye biodegradation. The bacterial species were identified as Lysinibacillus fusiformis sp. and Lysinibacillus macrolides sp. respectively, using 16S rRNA. The most potential bacterial species, i.e. Lysinibacillus fusiformis KLM1 (MW599200), was used for Congo red dye biodegradation in an anaerobic moving bed bioreactor. The experiments were designed using a central composite design (CCD) of response surface methodology (RSM) to optimize the process variables such as dye concentration, agitation speed, and bio carrier filling ratio. The maximum congo red dye removal efficiency of 89.28% was found at optimum conditions (dye concentration of 60 mg/L, agitation speed 70 RPM, and bio carrier filling ratio 45%). The performance of an anMBBR was evaluated at different inlet loading rates under optimized conditions. The removal efficiency of CR dye was found to be highest at lowest inlet loading and flow rates. The MSK model was successfully employed to calculate kinetic parameters: maximum CR removal rate (U_{max} of 0.21 g/L.d) and saturation constant (K_B of 0.23 g/L.d).

In the next study, the objective of this work was to develop a low-cost and efficient biocarrier for biodegradation of azo dye (i.e., Congo red (CR) dye). The potential bacterial species, i.e., *Lysinibacillus fusiformis KLM1* and *Lysinibacillus macrolides KLM2*, were isolated from the dye-

contaminated site. These bacterial species were immobilized onto the polypropylene-polyurethane foam (PP-PUF) and employed in a moving bed biofilm reactor (MBBR) to treat CR dye. The effectiveness of the MBBR was investigated by operating the bioreactor in a continuous mode at various initial CR dye concentrations (50 - 250 mg/L) for 113 days. The removal efficiency was found in the range of 88.4 - 64.6 % when the initial dye concentration was varied from 50 to 250 mg/L. The maximum elimination capacity (EC) of 213.18 mg/L.d was found at 250 mg/L of CR dye concentration. In addition, the CR dye utilization rate in the MBBR was studied by using two kinetics, namely, First-order and Second-order (Grau) models. The high regression coefficients ($R^2 > 0.97$) and the satisfactory root mean square (RMSE) values (0.00096 – 0.02610) indicated the reasonable prediction of CR dye degradation rate by the Grau model.

In this work, an effort has been made to treat the dye-containing wastewater using modified biocarriers in packed bed bioreactors (PBBRs). *Lysinibacillus* sp. immobilized polyurethane foam combined with activated carbon, and sodium alginate was used for the biodegradation of Congo red dye. The optimum values of process time, glucose concentration, and dye concentration were obtained to be 4.0 days, 2.0 g/L, and 50 mg/L, respectively. The maximum dye removal efficiency (RE) of 92.63 % was obtained at the optimized conditions. The continuous PBBR offered a maximum RE and elimination capacity of 90.73% and 10.89 mg/L. d, respectively, at an inlet loading rate of 12 mg/L. d. Moreover, the growth kinetic of *Lysinibacillus* sp. was well predicted by the Andrew-Haldane model with a regression coefficient of 0.98.

6.2: Future scope

- Know how obtained in this study can be used to scale up the bioreactors for real-time applications.
- The application of MBBR and PBBR for the effective biodegradation of dye using polyurethane foam-polypropylene immobilized microorganisms.
- Understanding mass transfer, bioreactor design and modeling, bio reaction kinetics, and carrier selection are essential to comprehend how bioreactors work.
- Additional research is necessary to assess and develop biological processes for the mineralization and degradation of these and other significant groups of dyes